

REQUIREMENTS FOR PHOTOGRAMMETRIC DATA COLLECTED IN NATIONAL GEODETIC AND CARTOGRAPHIC RESOURCE

W. Izdebski, A. Andrzejewski, A. Bober

Head Office of Geodesy and Cartography, Warsaw, Poland
(waldemar.izdebski, adam.andrzejewski, anna.bober)@gugik.gov.pl

Commission I, WG I/10

KEY WORDS: national geodetic and cartographic resource in Poland, photogrammetric data, data quality control

ABSTRACT:

The Registers of the national geodetic and cartographic resources deliver reference information for other resources of Spatial Data Infrastructure (SDI). It is essential that the good quality information from public resources has a direct impact on the correctness of the conducted processes and analysis of public and private sectors. Besides knowledge about quality of data is crucial for users to compare datasets to determine which best fulfils for their needs. Therefore requirements for data are a vital to the process of selecting a data set in that the value of data are directly related to its quality. This paper presents concept of Polish Registers for photogrammetric data: technical standards for aerial imagery, elevation data, orthophotomaps, among others completeness, accuracy and spatial characteristics. In addition, article presents current state of the photogrammetric data in the Polish Geodetic and Cartographic Resource.

1. INTRODUCTION TO PHOTOGRAMMETRIC REGISTERS

The basic requirements for photogrammetric data are defined in *The Geodetic and Cartographic Law* (Polish Parliament, 1989), *Regulation regarding databases on aerial and satellite imagery, orthophotomap and a digital terrain model* (Ministry of Interior and Administration, 2010) and *Regulation regarding the National Spatial Reference System* (Councils of Ministers, 2011). More detailed requirements are described in technical standards for the tender.

The national geodetic and cartographic resource in Poland is divided into three groups of geodetic and cartographic documentation: the central resource, voivodeship resources and district resources. The central resource is provided by Head Surveyor of the Country and contain data sets and databases of spatial data infrastructure including photogrammetric data: aerial and satellite images, orthophotomaps and digital terrain models. All registers include metadata describing them and the services they perform in accordance with the Act on Spatial Information Infrastructure (Polish Parliament, 2010). The data stored in national geodetic and cartographic resource in Poland are published in the national broker: www.geoportal.gov.pl. The web application lets browse and search spatial data sets and services which belong to the National Spatial Data Infrastructure. Besides, Head Office of Geodesy and Cartography provides web services, such as view services (WMS, WMTS), discovery services (CSW) and download services (WFS, ATOM, WCS). These allow web clients to query and receive spatial data in the form of image, vector or coverage data.

The following photogrammetric information is verified and collected in the national geodetic and cartographic resource:

- in the register of aerial and satellite images:
 - data sets of aerial and satellite imagery,
 - flight parameters, such as the type of aircraft, helicopter or name of the satellite, date of the flight, flight altitude, place and time of flight, meteorological conditions: cloudiness,

visibility, fog, turbulence, drift angle, azimuth

- technical parameters of the camera
- data specifying the spatial location of the analog measuring camera,
- angles ω , ϕ , κ
- metadata
- in the register of orthophotomaps:
 - data sets of orthophotomaps
 - metadata
- in the register of digital terrain model:
 - LIDAR data
 - Points (mass, characteristic and height) and lines (structural, contour lines, closed lines describing planar areas, closed lines describing areas excluded from measurements) obtained by photogrammetric methods
 - Digital elevation model
 - Digital surface model
 - Metadata

The Head Office of Geodesy and Cartography use this law regulations and specifications to acquire photogrammetric data and to create consistency across all data and partner-funded photogrammetric collections from public fund. Local conditions and application in any given project, or the preferences of partners may mandate more stringent requirements. In these cases, the Head Office of Geodesy and Cartography support or encourage to the collection of more detailed, accurate, or value-added data. Local conditions may also prevent a given collection from meeting these specifications (for example writing format).

2. REQUIREMENTS FOR PHOTOGRAMMETRIC DATA COLLECTED IN NATIONAL GEODETIC AND CARTOGRAPHIC RESOURCE

2.1 Quality of photogrammetric data in other countries

Information about quality of spatial data allows a data producer to evaluate how well a data set meets the criteria set forth in its product specification and assist data users in evaluating a product's ability to satisfy the requirements for their particular application (ISO19157:2013). Therefore it was very important to prepare quality control model for aerial imagery, orthophotomaps and elevation data, including requirements stemming from legal regulations and technical standards, such as correctness, consistency and accuracy. It is essential that data into national geodetic and cartographic resource has defined standard.

In comparison to other countries the basic difference in photogrammetric data is current horizontal and vertical coordinate systems and spatial characteristic (comparing to current technical specification for Great Britain, Texas-*Statement of Work for the Acquisition and Production of High Resolution Orthoimagery in Texas, 2019*, Virginia- *Digital Orthoimagery Base Specification V1.0, 2014*). Photogrammetric data in polish resource are defined in plane rectangular coordinates PL-1992 (for topographic scale) and PL-2000 (for large scale), that use Gauss-Krüger projection to implement a one-zone system with a 19° meridian axial (PL-1992) and the realization of a four-zone system (with a width of 3° each) with 15°, 18°, 21° and 24° meridians axial (PL-2000). In the case of vertical reference frames, vertical reference frames are marked by symbols PL-KRON86-NH and PL-EVRF2007-NH, which are the mathematical and physical implementation of the European Vertical Reference System (EVRS). The vertical reference frame PL-KRON86-NH is associated with the tide-gauge in Kronstadt, PL-EVRF2007-NH is associated with the tide-gauge in Amsterdam.

In case of technical parameters, Poland is in the top of European countries in the field of LIDAR data. Density 12 points/ m² for cities, 4 points/m² for other areas and accuracy (xy: 15 cm-20 cm, z: 20cm) of LIDAR data is one of the best in Europe: Sweden - 2 points/m², Westfalia > 4 points/m², Netherlands > 8 points/m² (Vosselman, 2018). Aerial photography and orthophotomaps are very similar to other European countries (RGB/CIR, pixel size 3-10cm for cities and 10-25 cm for other areas).

What is very important data specifications mostly do not define the methodology and technology of processing, they define only final products.

2.2 Basic requirements for aerial imagery

Quality criteria of aerial imagery for polish resource are similar to another countries in Europe. The difference are mainly connected with writing format. Aerial imagery in polish resource must be written with following parameters:

Color	RGB/CIR
Format	Tiff
Radiometric resolution	8 bit/band
Overview	Gaussian method
Compression	JPEG, Q=4/Q=5

Table 1. Aerial imagery- parameters of writing

Other requirements for photogrammetric imagery are similar to other European countries:

1. Overlap shall be sufficient to provide full stereoscopic coverage of the areas to be photographed. Endlap shall average not less than sixty percent (60%). Sidelap shall average not less twenty-five- thirty percent (25-30%),
2. Aerial photography shall not be undertaken when the sun angle is less than twenty (20-30) degrees above the horizon.
3. Each camera shall have been calibrated, tested, and certified. In practice, current legal regulation allow only large format cameras.
4. The axis of the camera should be in a vertical position. The tilt (departure from the vertical) should not exceed four degrees (3°) or the relative tilt between images or strips exceed six degree (5°)
5. Aerial photography shall not be taken when the ground is obscured by haze, snow, foliage, flooding conditions or when clouds or cloud shadows.
6. Photography shall be executed so as to minimize image movement at the moment of exposure.
7. It's necessary to use GCP.

GSD depends on area of aerial photography and on application. Nowadays, normally for cities/counties the standard is 3-10 cm, for other areas 10-25cm.

The most common reason for aerial imagery rejection is fuzzy imagery caused by image movement at the moment of exposure. Sometimes imagery are not correct geometrically (values of ω , ϕ , κ are exceed allowed values 3,3,15 degree).

2.3 Basic requirements for orthophotomaps

Orthophotomaps in national geodetic and cartographic resource must meet the following criteria:

Colour	RGB/CIR
Format	GeoTiff
Radiometric resolution	8 bit/band
Overview	Gaussian method
Compression	JPEG, Q=4/Q=5
orthorectification	Bilinear/bicubic
RMSExy	<=3pixel size

Table 2. Orthophotomaps- parameters of writing

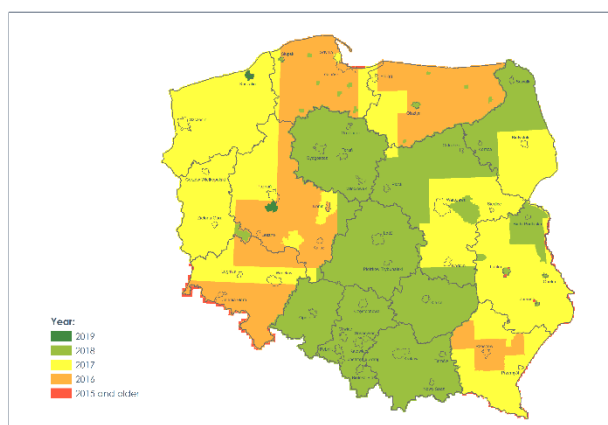
Besides:

1. Orthophotomaps must be created from stereoscopic aerial imagery collected in national geodetic and cartographic resource.
2. Orthophotomas must be geometrically correct, without errors caused by wrong Digital Elevation Model or wrong aerotriangulation.
3. Aerotriangulation (AT) used in the orthorectification process, shall consist of a minimum of exterior orientation parameters, refined image coordinates and adjusted ground coordinates.
4. Orthoimagery must be free from errors connected with image mosaicking. Specular reflections and other artifacts should be minimized, especially in developed areas. Above ground features appearing in the orthoimage imagery, such as building roof tops, towers, shall not be clipped at seamlines or between individual image files.
5. Elevation data used during the orthorectification process shall have sufficient resolution and density to produce orthoimagery that meets the horizontal accuracy requirements.

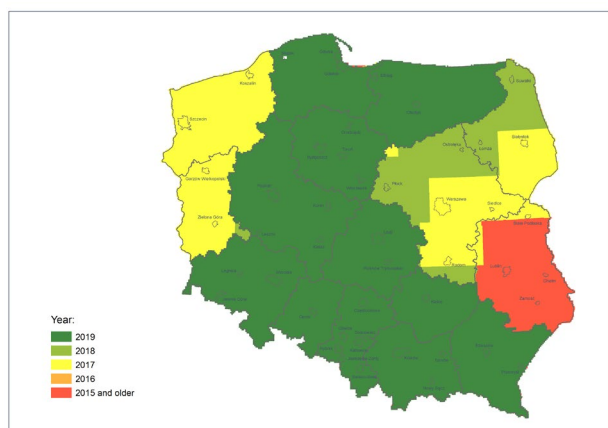
The most common reason for orthophotomaps rejection are geometrical errors caused by wrong Digital Elevation Model, sometimes there are defects connected with wrong image mosaicking.

Pixel size of orthophotomaps depends on area and on application. Normally for cities/counties the standard is 3-10 cm, for other areas 10-25cm. Nowadays cover of Poland of 25 cm orthophotomaps takes place in 3-years cycle, 10 cm and better (cities/counties) in 5-years cycle.

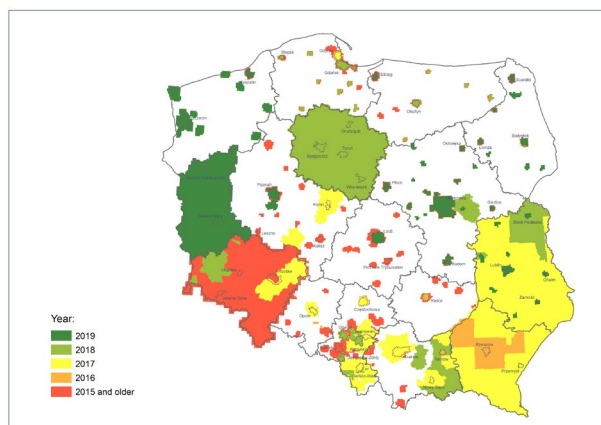
The figure figure 1 presents actual state of the latest orthophotomaps, figure 2 presents planed state of 25cm orthophotomaps in national resource on the end of 2019 year, figure 3 presents planed state of 10 cm orthophotomaps on the end of 2019 year, and figure 4 presents planned state of all orthophotomaps on the end of 2019 year:



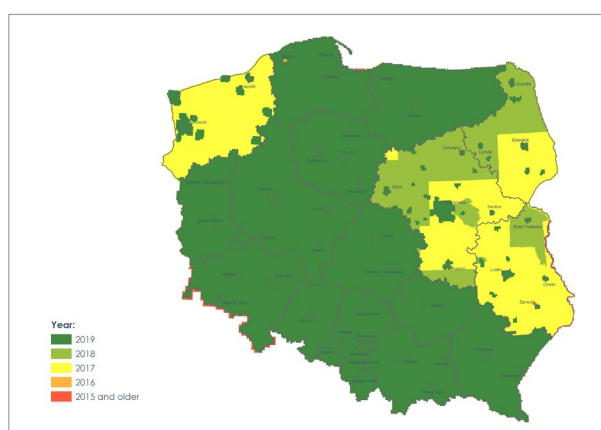
The figure 1. Actual state of latest orthophotomaps in national resource, state on the July 2019



The figure 2. Planed state of 25 cm orthophotomaps in national resource on the end of 2019 year



The figure 3. Planed state of 10 cm orthophotomaps in national resource on the end of 2019 year



The figure 4. Planned state of orthophotomaps in national resource on the finish of 2019 year.

2.4 Basic requirements for LIDAR DATA

LIDAR data for national geodetic and cartographic resource must meet the following criteria:

Absolute vertical accuracy	$\leq 15\text{cm}$
Absolute horizontal accuracy	$\leq 30\text{cm}$
Relative vertical accuracy	$\leq 8\text{cm}$
Relative horizontal accuracy	$\leq 20\text{cm}$
LIDAR density	12 p/m ² for cities; 4 p/m ² for other areas
Format	LAS, version 1.2, POINT DATA RECORD FORMAT 3.
Classification	ASPRS Standard LiDAR Point Classes

Table 3. LIDAR data- parameters of writing

Besides:

1. Scan angles $> \pm 25$ are not allowed
2. Registration of a minimum four "echoes" is required.
3. It is required to register the intensity of the reflected signals
4. The average distance of the LIDAR points in the flight direction and in the transverse direction ranged from 1: 1.5 to 1.5: 1.
5. LIDAR data should be classified: 0 – Created, never classed, 2- Ground, 3- Low vegetation, 4- Medium

- Vegetation, 5- High vegetation, 6- Building, 7- Low points (noise), 9- Water, Overlap points.
6. 99% LIDAR points must be correctly classified to ground class
7. 95% LIDAR points must be correctly classified to class used to generation digital surface model.
- 8.

The most common reason for LIDAR rejection are errors caused by wrong classification and incorrect header of LAS files.

Density of Lidar points depends on area and on application. Normally for cities/counties the standard is 12 p/m², for other areas 4p/m². Cover of Poland of LIDAR data is planned in 6-years cycle.

The figure 5 below presents actual state LIDAR data in national resource, figure 6 presents planned state on the finish of 2019 year:

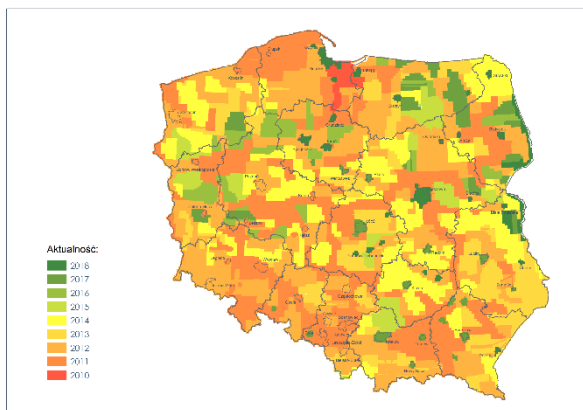


Figure 5 Actual state LIDAR data in national resource

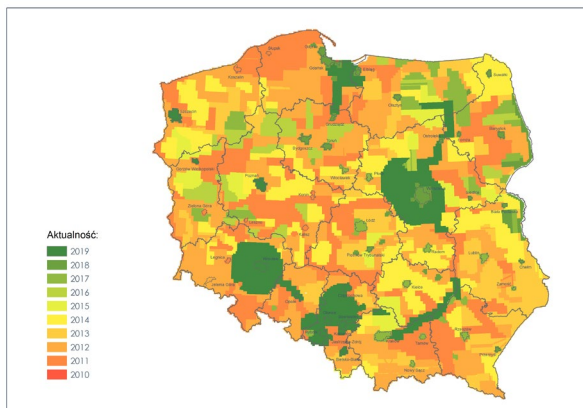


Figure 6 Actual state LIDAR data in national resource

3. PHOTOGRAMMETRIC DATA AS A PART OF NATIONAL SPATIAL DATA INFRASTRUCTURE

The term of Spatial Data Infrastructure SDI was introduced by U.S. Vice President Al Gore and propagated by international organisations such as FIG or ISPRS (Konecny, 2005). SDI fundamentally means facilitation and coordination of the exchange and sharing of spatial data between stakeholders from different jurisdictional levels in the spatial data community (Williamson, Rajabifard, 2003). Therefore, in the national context, develop and success of a SDI depends mainly on the availability of data. The key components of SDI are geoportals (most visible part of SDI), metadata and search functions (Hu, Li, 2017). According to art. 13 section 2 of the Law of 4 March 2010.

Spatial data infrastructure "Surveyor General for Poland establishes and maintains publicly available register of spatial datasets and services covered by the spatial data infrastructure and gives them uniform identifiers." and Regulation of the Minister of Investment and Development of 28 November 2018 amending the regulation on the registration of spatial data sets and services covered by the spatial information infrastructure. "The register are kept in the IT system whose database is integrated with the geoportal of the spatial information infrastructure, referred to in article 13 section 1 of the Act of 4 March 2010 on Spatial Data Infrastructure" the register of spatial data sets was made available.

Figures below shows register of orthophotomaps (Figure 7) and elevation (Figure 8):

Numery porządkowe	203
Data otrzymania zgłoszenia przez Głównego Geodetę Kraju	2011-02-25
Data ujawnienia zbioru danych przestrzennych w ewidencji	2011-02-28
Identyfikator zbioru danych przestrzennych	PL_P2GK-203
Nazwa organu administracji, który zgłosił zbiór danych przestrzennych do ewidencji	Główny Geodeta Kraju
Nazwa jednostki w której prowadzony jest zbiór	Główny Urząd Geodety i Kartografii
REGION jednostki w której prowadzony jest zbiór	0122270098
Nazwa zbioru danych przestrzennych	Ortofotomapa
Kod oraz skrócona nazwa tematu danych przestrzennych, z którymi łącznie jest zbiór danych przestrzennych	2-3 Ortozobry
TYTUŁ	PL
Opis: do którego usługi jest zbiór danych przestrzennych	public
Dane identyfikujące przepisy prawa, na podstawie których prowadzony jest zbiór danych przestrzennych	Ustawa z dnia 17 maja 1969 r. Prawo geodezyjne i kartograficzne, art. 4 ust. 1a pkt 11
Wykaz dostępnych usług danych przestrzennych związanych ze zbiorem danych przestrzennych	wyszczególnić: http://mapy.geoport.gov.pl/wss/service/CSW/guest/CSWstartUp opracowania: WMS: http://mapy.geoport.gov.pl/wss/service/imag_query/ORTO/MapServer/WMSServer WMTS: http://mapy.geoport.gov.pl/wss/service/WMTS/guest/wmts/ORTO
Opis: adres, na którego adresie	opublikować: adres geolokacji usługi
Wskaz	58822 adresów w województwie PL

Figure 7. National register of orthophotomaps
<https://integracja.gugik.gov.pl/eziudp/index.php?edycja=16358>

Numar pozareglas	205
Data stiermenia zgłoszenia przez Olszowego Geodetę Kraju	2011-02-25
Data ujawnienia zbioru danych przestrzennych w ewidencji	2011-02-28
Identyfikator zbioru danych przestrzennych	PL_PCGK.205
Nazwa organu administracji, który zgłosił zbiór danych przestrzennych w ewidencji	Olszowy Geodeta Kraju
Nazwa jednostki w której prowadzony jest zbiór	Olszowy Urząd Geoducji i Kartografii
REGON jednostki w której prowadzony jest zbiór	022276000
Nazwa zbioru danych przestrzennych	Numerowy Model Terenu
Wielkość i składowa nazwa tematyczna danych przestrzennych, z jakimi są związane zbiór danych przestrzennych	3.2.1 - Ukształcanie terenu
TEKST	PL
Podpis	Polska
Opisuje, że któregoś z adresów się zbioru danych przestrzennych	
Dane identyfikacji procedury z tym, że podawanie kierunku prowadzonego jest zbiór danych przestrzennych	Ustawa z dnia 17 maja 1969 r. Prawo geodezyjne i kartograficzne, art. 4, ust. 1a, pkt 11
Wskazuje na adresy danych przestrzennych związanych z zbiorem danych przestrzennych	http://mapy.geoport.gov.pl/wcs/service/CSW/geoport/CWSWStartup ogólny: WMS: http://mapy.geoport.gov.pl/wcs/service/wmsimg/geoport/HS00K_HISPO/ImageServer/WMSViewer WMTS: http://mapy.geoport.gov.pl/wcs/service/WMTS/geoport/wmts/HS00K_HISPO http://mapy.geoport.gov.pl/wcs/service/WMTS/geoport/wmts/HS00K_CHI_N WMTS: http://mapy.geoport.gov.pl/wcs/service/WMTS/geoport/wmts/HS00K_CHI_N pobierania: http://mapy.geoport.gov.pl/wcs/service/ATOM/MapData/atom/CODGK_NMT100

Figure 8. National register of elevation
<https://integracja.gugik.gov.pl/eziudp/index.php?edycja=22169>

Head Office of Geodesy and Cartography in Poland provided services of photogrammetric data sets: WMS, WMTS, CSW, WFS, ATOM, WCS. It can be integrated into any mapping application for web application allowing for an easy-to-use way to exploit the data. The table 4 presents provided web services for photogrammetric data.

WMS	• Orthophotomap http://mapy.geoportal.gov.pl/wss/service/img/guest/ORTO/MapServer/WMSServer • Orthophotomap - archival http://mapy.geoportal.gov.pl/wss/service/img/guest/ORTO_TIME/MapServer/WMSServer • Digital Elevation Model ISOK – Hipsometry http://mapy.geoportal.gov.pl/wss/service/wmsimg/guest/ISOK_HipsoDyn/ImageServer/WMSServer • Digital Elevation Model LPIS – Hillshade http://mapy.geoportal.gov.pl/wss/service/img/guest/CIEN/MapServer/WMSServer • Digital Elevation Model LPIS – Hipsometry http://mapy.geoportal.gov.pl/wss/service/img/guest/HIPSO/MapServer/WMSServer • Aerial photography – indexes http://mapy.geoportal.gov.pl/wss/service/pub/guest/G2_SKOROWIDZE_ZDJECIA/MapServer/WMSServer
WMTS	• Digital Elevation Model ISOK – Hipsometry http://mapy.geoportal.gov.pl/wss/service/WMTS/guest/wmts/ISOK_HIPSO • Digital Elevation Model ISOK – Hillshade

	http://mapy.geoportal.gov.pl/wss/service/WMTS/guest/wmts/1/SOK_CIEN - Digital Elevation Model ISOK – Hillshade and Hipsometry http://mapy.geoportal.gov.pl/wss/service/WMTS/guest/wmts/1/SOK_CIENHIPSO - Digital Elevation Model LPIS – Hipsometry http://mapy.geoportal.gov.pl/wss/service/WMTS/guest/wmts/HIPSO - Digital Elevation Model LPIS – Hillshade http://mapy.geoportal.gov.pl/wss/service/WMTS/guest/wmts/CIEN - Orthophotomap http://mapy.geoportal.gov.pl/wss/service/WMTS/guest/wmts/ORTO
CSW	Katalog Metadanych - krajowy http://mapy.geoportal.gov.pl/wss/service/CSW/guest/CSWStartUp
WFS	- Digital Elevation Model http://mapy.geoportal.gov.pl/wss/service/img/httpauth/NMT/MapServer/WFSServer - Indexes http://mapy.geoportal.gov.pl/wss/service/pub/httpauth/G2_skorowidze_WFS/MapServer/WFSServer
ATOM	NMT_100 – Digital Elevation Model (100 m) http://mapy.geoportal.gov.pl/wss/service/ATOM/httpauth/atom/CODGIK_NMT100
WCS	- Hipsometria http://mapy.geoportal.gov.pl/wss/service/img/guest/HIPSO/MapServer/WCSERVER - Ortofotomapa http://mapy.geoportal.gov.pl/wss/service/img/guest/ORTO/MapServer/WCSERVER - Cieniowanie http://mapy.geoportal.gov.pl/wss/service/img/guest/CIEN/MapServer/WCSERVER

Table 4. Web services for photogrammetric data provided by Head Office of Geodesy and Cartography

Furthermore, national photogrammetric data sets are published in the national broker: www.geoportal.gov.pl. The web application lets browse and search spatial data sets and services for aerial imagery, orthophotomaps and elevation data.

The figure below shows user interface of national geoportal with loaded orthophotomaps and indexes:

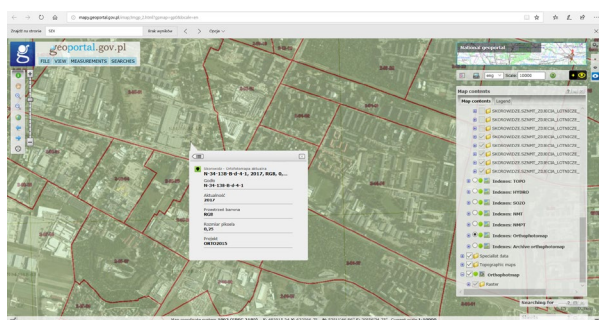


Figure 7. Screenshot of Polish geoportal presenting orthophotomaps.

What is very important, photogrammetric data and services are important part of national Spatial Data Infrastructure and deliver reference information for other resources. For example, LIDAR data was reference data for 3d building models- CityGML LOD1 (almost 9 million buildings) and LOD2 (above 10 million buildings) created by Head Office of Geodesy and Cartography. The model buildings, published by ATOM service, are very popular among users. The present number of downloads city model buildings is about 22016, what is success of national SDI. Figure 8 presents 3d model buildings- LOD1 for Poland:



Figure 8. Screenshot of 3d model building- LOD1.

4. CONCLUSIONS

Requirements for aerial imagery, orthophotomaps and elevation data are necessary to ensure consistency of national photogrammetric resource. Polish requirements for photogrammetric data are very similar to European standards.

Photogrammetric data and services are important part of national Spatial Data Infrastructure and deliver reference information for other resources. Furthermore develop and success of national SDI depends mainly on the availability of data.

REFERENCES

Act of Polish Parliament, 1989, The geodetic and cartographic law, Warsaw

Act of Polish Parliament, 2010, Spatial Information Infrastructure, Warsaw

Regulation of Minister of Interior and Administration regarding databases on passenger and service images as well as an orthophotomap and a digital terrain model, Warsaw, 2010
PN-EN ISO 19157 Geographic information – Data quality
Regulation of Councils of Ministers Regarding the National Spatial Reference System, Warsaw, 2011

Regulation of the Minister of Investment and Development amending the regulation on the registration of spatial data sets and services covered by the spatial information infrastructure, Warsaw, 2018

Great Britain- specification for spatial data: <https://www.ordnancesurvey.co.uk/>

Statement of Work for the Acquisition and Production of High Resolution Orthoimagery in Texas v9, https://tnris.org/static/documents/stratmap/tx_orthoimagery_so_w_v9.pdf

Rufe, P., P., 2014, Digital Orthoimagery Base Specification V1.0, <https://pubs.usgs.gov/tm/11/b5/pdf/tm11-B5.pdf>
Konecny, G., 2005, The cadastre as part of a spatial data infrastructure for developing countries, E/CONF.96/I.P.21, https://unstats.un.org/unsd/geoinfo/RCC/docs/rcca8/IP/8th_UN_RCCA_econf.96_IP21.pdf

Williamson, I., P., Rajabifard, A., 2003, Spatial data infrastructures: concept, SDI hierarchy and future directions, https://www.researchgate.net/publication/228581533_Spatial_data_infrastructures_concept_SDI_hierarchy_and_future_directions

Hu, Y., and Li, W. (2017). Spatial Data Infrastructures. *The Geographic Information Science & Technology Body of Knowledge* (2nd Quarter 2017 Edition), John P. Wilson (ed.). DOI: 10.22224/gistbok/2017.2.1

Vosselman, G., (2018) Point clouds and derivatives for nationwide geospatial information, <https://www.isprs.org/tc2-symposium2018/>